

Healthcare Reform in China: Consequences and Policy Implications

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Preface

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All remaining mistakes are mine.

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Abstract

China has continuous reforms in health sector since its economic reform in 1978. The purpose of this thesis is to examine the health sector in China and provide policy recommendations for healthcare reforms. A historical review on the reform process provided implications of challenging problems in China's health sector. Hospitals are classified into three grades and prices for healthcare services are regulated. It is believed that efficiency could be improved by applying more appropriate pricing scheme. A quality competitive model of hospitals under regulated price was developed in this thesis. The author analyzed the effect of expanding price difference among hospitals within the model. The results of the model demonstrated that hospitals have higher incentive to improve healthcare quality after increasing regulated price. However, the impact of expanding price difference depends on other socioeconomic conditions. Hence policymakers need to pay careful attention to various aspects of the health sector when applying this strategy.

Key words: healthcare reform, hospital competition, price regulation, healthcare quality

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1 Introduction

China launched a new plan of healthcare reform in 2009 aiming at solving the “kan bing nan, kan bing gui” problem (decreasing access to healthcare and increasing expenditure on healthcare) in the health sector. The phenomenon that high-grade hospitals are overcrowded while low-grade hospitals are underutilized is one of the most debated topics in healthcare reform. In China, public hospitals are classified into three grades according to health resources and functions. Generally, high-grade hospitals are able to provide higher quality healthcare services and treat more complicated diseases. Prices for healthcare services are regulated. Historically, there is little price difference for the same treatment provided by different hospitals. Some believe that expanding price difference among hospitals can mitigate demand pressure on high-grade hospitals and improve the utilization rate of low-grade hospitals; and suggest that pricing leverage should be used to coordinate demand and supply of healthcare (Hu, 2006; Yin, 2009). This suggestion has been accepted by some provinces (e.g., Jiangsu Province and Anhui Province) and a trial project has been launched. Hence it is very important to understand the effects of changes in regulated prices on the supply of and demand for healthcare services.

The purpose of this thesis is to provide a theoretical model of the strategies of high-grade hospitals and low-grade hospitals facing regulated prices, analyze the effect of expanding price difference and find some implications for the health sector reform in China.

Existing models of hospital behaviours or physicians’ behaviours under regulated prices mainly focus on the pricing structure. Eggleston and Yip (2004) have developed a model of public-private hospital competition under regulated prices. They note that prices of basic services are regulated at a low level to assure access for basic healthcare in China while prices for other services are set high to allow hospitals to recover revenue. Their results show that the distorted price structure leads to over/under use of services by profitability, which in turn fuels cost escalation and reduces access for those who cannot afford to self-pay for care. Chen, Liu and Wang (2008) have developed a vocational choice model of doctors under regulated price. People’s willingness to enter the healthcare market and hence the supply of healthcare are closely associated with the regulated prices for healthcare. When prices could not reflect physicians’ ability, people with high ability choose not to enter the

market. The supply of high quality level of healthcare services could then not meet people's demand and hence access to high quality healthcare services is limited. Physicians who are already in the healthcare market would induce patients to use more pharmaceuticals to compensate their income which in turn leads to increasing expenditure on healthcare. They conclude that regulated price is the root cause of problems confronting the health sector in China and recommend softening price regulation to solve these problems.

The existing literature does not capture the characteristics of hospital classification and demand-supply situation of different grade hospitals in China. In this thesis, we develop an asymmetric duopoly model to capture competition between different grade hospitals. In our model, we assume hospitals choose quality levels of healthcare services to maximize their profits under regulated prices. Patients decide which hospital to choose by comparing qualities and prices of healthcare services provided by different hospitals.

We find that a hospital has higher incentive to improve healthcare quality after increasing its price. Then competition between hospitals urges other hospitals to improve quality also. But the equilibrium demand for a hospital's health service increases depends on not only its quality but also its price. The effect of expanding price difference on demand for healthcare services depends on the price elasticity of demand for healthcare services, hospitals' cost functions and the relative price change of different hospitals. Hence policymakers need to pay careful attention to various aspects of the health sector when applying this strategy.

The rest of the thesis is organized as follows. The next chapter provides a historical review of the health sector reform in China and summarizes implications of the reform. The historical review introduces the evolution of the health sector in China after economic reform in 1978. I describe the main challenging implications of the reform process and proceed to discuss the last one in detail. The third chapter develops the quality competitive model of hospitals and displays the analytic results. The last chapter contains the conclusions of results and policy recommendations.

2 Literature review

2.1 Historical review of the health sector in China

China had an almost thirty-year period of planned economy after its foundation in 1949 and started its economic reform from a planned economy to a market economy in 1978 (commonly called as “reform and opening-up” in China). Along with the development of economic reform in various areas, the health sector was inevitably affected. Old systems were collapsed or outdated under the new socioeconomic environment. Following this, a series of reforms toward marketization and modernization in the health sector have been piloted and carried out. The question whether the health sector should be market-led or government-led has sparked heated debates and never ceased since the early 1990s. Wang (2008) made a review on reforms in the health sector, and divided the process after 1978 into five periods. In this section, I will follow Wang’s division and introduce a review on evolution and reform in China’s health sector.

2.1.1 Period I (1978-1985)

This was a transitional period of reconstruction and reform in the health sector. Before 1980, the aim of the health sector administration was restoration and reconstruction of the healthcare system which was heavily destroyed during the Cultural Revolution (1966-1976). After 1980, emphasis of healthcare was gradually transferred to reform in the health sector (Wang, 2008).

Policy: In 1979, the former Minister of Health Qian Xinzong, proposed to “use economic means to administer the health sector” in an interview. And at the national conference of health bureau directors, it was claimed that “the (current) emphasis of the health sector administration should be the modernisation of the health sector”. That same year, the Ministry of Health applied “fixed subsidies, economic measurement as well as punishment and reward according to results”.

In August 1980, the State Council approved and transmitted the “consulting report on allowing private healthcare practice” submitted by the Ministry of Health, which marked the start to break the situation of all public-owned hospitals.¹

Evolution: In rural areas, over 90% of the population was covered by the Cooperative Medical Scheme (CMS) before 1978. In urban areas, “the Government Insurance Scheme and Labour Insurance Scheme provided almost free healthcare to the employees of the government agencies and public institutions”. However, the CMS gradually collapsed following the collapse of collective production. After that for a long time, most of the rural population had no health insurance coverage but paid for services out-of-pocket (Tang et al., 2008).

2.1.2 Period II (1985-1992)

1985 was the first year that the healthcare reform was officially launched in China. The core ideas of the reform at that time were decentralization of power, allowing hospitals to retain larger share of profits, and expansion of hospital autonomy.

Policy: In April 1985, the State Council approved and transmitted a document submitted by the Ministry of Health.² The document proposed to “reform, relax policies, streamline administration and decentralize, and raise funds from multi-channels”, which unveiled a prelude to the transformation of healthcare institutions.

In 1989 the State Council approved and transmitted the document “suggestions on expansion of medical and healthcare services”.³ The document proposed five measures: (1) actively promote various forms of contract and responsibility system;⁴ (2) encourage health

¹ Ministry of Health, (1980): Guanyu Yunxu Geti Yisheng Kaiye Xingyi Wenti de Qingshi Baogao (consulting report on allowing private healthcare practice), policy document.

² Ministry of Health, (1985): Guanyu Weisheng Gongzuo Gaike Ruogan Zhengce Wenti de Baogao (Report on Several Policies concerning Healthcare Reform), (Guo Fa [1985] No. 62), policy document.

³ Ministry of Health, Ministry of Finance, Ministry of Personnel, the State Price Bureau and the State Administration of Taxation(1989): “suggestions on expansion of medical and healthcare services”, (Guo Fa [1989] No. 10), policy document.

⁴ The contract and responsibility system “was a practice in China starting from 1981. The major change from the past egalitarian distribution method was that individual companies and managers were now responsible for their own losses and

institutions to provide paid supplementary service; (3) further adjust fees for healthcare services;(4) health preventive and protective institutions would provide paid services;(5) suggest public hospitals “*yi fu bu zhu, yi gong zhu yi*” (a policy requiring public healthcare institutions to carry out profitable production of side-products to recover revenue).⁵ Health institutions were exempted from tax for three years to carry out other businesses.

In November 1989, the Ministry of Health enacted the rule “Regulations for Hospital Classification”.⁶ Hospitals became classified into three grades according to hospital functions, hospital resources, medical facilities as well as physician expertise. The first grade hospitals are basic hospitals and community hospitals directly providing preventive medicine, diagnosis services, treatment services and convalesce services to its community. The second grade hospitals are district hospitals providing comprehensive healthcare services to more than one community and conducting certain level of teaching and researching tasks. The third grade hospitals are hospitals providing high-level and specialized healthcare services to more than one district and conducting higher education and researching tasks. Every three years, there is a hospital evaluation by the government. Hospitals participating in the evaluation get a score according to their comprehensive performance during the past three years. Within each grade, hospitals are further divided into three levels according to their evaluation score. For example, a third grade hospital is labeled as level A when it receives a score no less than 900 which represents outstanding performance in hospital management, technology, service quality and other aspects. A third grade level B hospital has a score between 750 and 899. When its evaluation score is lower than 750, a third grade hospital is labeled as level C and required to take concrete measures to improve its performance.

The reform during this period focused on management and operation mechanism. The government did not provide funding when implementing these healthcare reforms. Direct

gains by contract with the government. it was first adopted in agriculture and later extended to other sectors of the economy”(Juan Du, 2009).

⁵ For example, hospitals can set up pharmaceutical retaining stores and other related production to seek profit. In August 1988 Jintan Chinese Medicine Hospital set up a medical plastic material plant to implement the policy spirit.

⁶ See Appendix C for description in detail.

investment by the government in the health sector gradually reduced and hospitals were encouraged to embrace market mechanism for development.

2.1.3 Period III (1992-2000)

Policy: In September 1992, the State Council issued the document “Opinions on deepening healthcare reform”.⁷ By implementing the document spirit the Ministry of Health required hospitals to make new achievements on “*yi fu bu zhu, yi gong zhu yi*”. The government gave fixed subsidies to hospitals. Hospitals were required to increase revenue by economic means. This health policy stimulated hospitals’ profit-driven behaviours, and also affected hospitals’ role as public welfare institutions, which became the root cause of problems in the health sector - decreasing access to and increasing expenditure on healthcare service (“kan bing nan, kan bing gui”).

Evolution: “Although the majority of Chinese health facilities are publicly owned, they rely heavily on revenue-generating activities for financial survival. Consequently, while most health facilities are “public” in terms of ownership, they are really “private, for-profit” in terms of behavior. As of the early 1990s, government subsidies for public health facilities have represented a mere 10% of the facilities’ total revenues. To keep healthcare affordable, the government sets prices for basic healthcare below cost. At the same time, the government wants facilities to survive financially, so it sets prices for new and high-tech diagnostic services above cost and allow a 15% profit margin on drugs” (Yip & Hsiao, 2009).

In May 1993, regarding hospitals’ profit-driven tendency, a series of debates was launched in the Ministry of Health. At the national working conference on the health sector issues, the deputy Minister of Health Yin Dakui openly opposed to marketization in the health sector and called for public-welfare property of healthcare services and basic social healthcare equality. Since then, debates on whether healthcare should be government-led or market-led have never ceased.

⁷ The State Council (1992): Guanyu Shenhua Weisheng Yiliao Tizhi Gaige de Jidian Yijian (Opinions on deepening healthcare reform), policy document.

2.1.4 Period IV (2000-2005)

During this period, different reform directions took place. Market-orientation has played a significant role but has also gradually exposed its drawbacks, especially after the outbreak of SARS. Market-led or government-led debates deepened and laid a foundation for next period's reform.

Policy: In February 2000, the State Council issued a policy document "Guidance Proposals on Institutional Reform in Urban Medicine and Pharmaceuticals System".⁸ Since then, hospitals are classified as for-profit and not-for-profit and administered accordingly. Not-for-profit public hospitals receive subsidies from the local government. For example, the municipal governments provide subsidies to municipal hospitals. County level hospitals were subsidized by their county government. For-profit hospitals have no subsidies from the government. Prices for health services of not-for-profit are set according to cost which deduced fiscal subsidies and spread income from pharmaceuticals. For-profit hospitals should implement the guidance price set by the government.

In January 2003, the State Council approved and transmitted "Proposals on Establishment of New Cooperative Medical Scheme".⁹ It proposes to launch a pilot project of the New Cooperative Medical Scheme (NCME) in small areas first and then gradually roll out nationwide. The aim of NCMS is to achieve universal coverage of basic social medical insurance for rural residents by 2010.

Evolution: In 2000, the first public hospital was privatized by auction in Suqian, Jiangsu Province. Suqian was the poorest city of Jiangsu province and the municipal government faced a debt burden at that time. Hospitals there had insufficient funding and sometimes the wages of workers in health institutions could not be paid on time. The then mayor intended to attract non-government capital by privatization of healthcare (Chow, 2006).

⁸ The Institutional Reform Office of the State Council, et al (2000): Guanyu Chengzhen Yiyao Weisheng Tizhi Gaige de Zhidao Yijian (Guidance Proposals on Institutional Reform in Urban Medicine and Pharmaceuticals System), (Guo Fa [2000] No.16), policy document.

⁹ The Ministry of Health, the Ministry of Finance and the Ministry of Agriculture (2003): Guanyu Jianli Xinxing Nongcun Hezuo Yiliao Zhidu de Yijian (Proposals on Establishment of New Cooperative Medical Scheme), (Guo Fa [2003], No.3), policy document.

The financial burden of healthcare on rural and urban households increased. According to statistical data, aggregate healthcare expenditures in China increased from 11.02 billion RMB in 1978 to 50.25 billion RMB in 2001.¹⁰ Individual out-of-pocket payments as a share of total health expenditure grew from 20% to 60% between 1978 and 2001.¹¹ People paid a significant fraction of their income on health expenditure. Yip and Hsiao (2009) state that “between 1993 and 2003, health expenditure as a share of household income increased, on average, from 8.2% to 10.7% in rural areas and from 6.0% to 7.2% in urban areas.”

2.1.5 Period V (after 2005)

On July 28 2005, “China Youth Daily” published a report made by the Development and Research Center of the State Council. By providing a review and reflection on healthcare reform over the years, the report concluded that China's health system reform was basically unsuccessful. This conclusion was mainly built on a market-led and government-led debate. Because of this report, 2005 became the starting point of a new round of healthcare reform.

Policy: At the beginning of 2006, the State Council issued the “Guidance on Development of Urban Community Healthcare Service” which announced to maintain the public-welfare nature of the healthcare service, emphasis on equity, efficiency and access of healthcare, keep government-led and encourage social involvement.¹² After that, extensive debates and conferences were launched regarding the direction of reform in the health sector.

In October 2006, the Sixth Plenary Session of the 16th Central Committee of the Chinese Communist Party adopted the “resolutions of the CPC Central Committee on major issues regarding the building of a harmonious socialist society.” It specifically identified healthcare reform as a national priority and the government has committed to strengthen government responsibility.

¹⁰ China Healthcare Statistical Yearbook 2009

¹¹ See Appendix B for data in detail.

¹² The State Council (2006): Guanyu Fazhan Chengshi Shequ Weisheng Fuwu de Zhidao Yijian(Guidance on Development of Urban Community Healthcare Service), (Guo Fa [2006] No.10), policy document.

In April 2009, China finally launched a new healthcare reform plan in which the Chinese government pledged a stronger role for government in ensuring equity in healthcare services. “The government announced that it will spend an additional 850 billion yuan over the next three years to invest in five specific areas: (1) expand insurance coverage with a target of achieving universal coverage by 2011, with significant demand subsidies for the rural population to enroll in the New Cooperative Medical Scheme (NCMS) and for the urban uninsured to enroll in the Urban Resident Basic Medical Insurance Scheme (URBMI); (2) increase government spending on public health services especially in lower-income regions with the goal of equalizing public health spending across regions; (3) establish primary-care facilities – community health centers in urban areas and township health centers in rural areas – which will serve as gate-keepers in the long run; (4) reform the pharmaceutical market; and (5) pilot test public hospital reforms” (Yip & Hsiao, 2009).

2.2 Implications of reform in the health sector

2.2.1 Increase insurance coverage

The establishment of the New Cooperative Medical Scheme (NCMS) for rural residents and Basic Medical Insurance for Urban Residents (BMISUR) were responses to accumulating evidence that limited health insurance has been one of the fundamental causes of unaffordable healthcare, and increasing public criticism on the government's negligence over the people's health insurance (Wagstaff et al., 2009). A significant proportion of the population had no health insurance of any form until the early 2000s.

The financial burden of healthcare on rural and urban households has increased significantly since 1978. Individual's out-of-pocket payments as a share of total health expenditure grew from 20% to 60% between 1978 and 2001.¹³ Increasing expenditure causes additional financial burden to poor households. “According to National Health Surveys, between 1998 and 2003, the proportion of people ill in the last two weeks who did not see care for financial reasons increased in both urban and rural areas” (Ministry of Health, 2004; Eggleston et al., 2008).

In 2003, China launched the NCMS program for rural residents. The objective is to establish universal coverage of basic health insurance for rural residents. The NCMS is financed by contributions from the central government, local governments, and individuals. When the program started in 2003, both the central and the local government subsidized 10 Yuan per capita each year in the poorer central and western regions, with individuals paying an additional 10 Yuan in annual premiums to enroll in the NCMS.¹⁴ In 2006, the minimum requirement for central and local government subsidy both increased to 20 Yuan per capita.¹⁵ In 2008, the central and local government further increased subsidy to 40 Yuan per capita, and individuals were required to pay 20 Yuan.¹⁶ Since 2010, the annual subsidies both from central government and local government have increased to 60 Yuan per capita with individual contribution increased to 30 Yuan.¹⁷

The Basic Medical Insurance Scheme for Urban Residents (BMISUR), covering children, the elderly, the disabled, and other non-working urban residents, started from 2007. The objective is to provide basic health insurance to the urban uninsured population. People covered by the BMISUR receive subsidies provided by governments ranging from 40 Yuan to 80 Yuan per capita, depending on the region's economic status and the social vulnerability of population groups.¹⁸ The BMISUR is a complementary scheme to the Basic Medical Insurance Scheme for Urban Employees (BMISUE). The BMISUE provides health insurance to urban employees. It evolves from the Government Insurance Scheme (GIS) and Labor Insurance Scheme (LIS), which dated back to the planned economy era and provided

¹³ See Appendix B for data in detail.

¹⁴ The Ministry of Health, the Ministry of Finance and the Ministry of Agriculture (2003): *Guanyu Jianli Xinxing Nongcun Hezuo Yiliao Zhidu de Yijian* (Proposals on Establishment of New Cooperative Medical Scheme), (Guo Fa [2003] No.3), Beijing, policy document.

¹⁵ The Ministry of Health et al. (2006): *Guanyu Jiakuai Tuijin Xinxing Nongcun Hezuo Yiliao Shidian Gongzuo de Tongzhi* (Notification of accelerating the pilot progress of New Cooperative Medical Scheme), Beijing, policy document. <http://www.moh.gov.cn/publicfiles/business/htmlfiles/mohncwsgls/s3581/200804/31106.htm>

¹⁶ The Ministry of Health and the Ministry of Finance (2008): *Guanyu Zuohao 2008 nian Xinxing Nongcun Hezuo Yiliao Gongzuo de Tongzhi* (Notification of the construction of rural New Cooperative Medical Scheme in 2008), Beijing, policy document. <http://www.moh.gov.cn/publicfiles/business/htmlfiles/mohncwsgls/s3581/200804/31097.htm>

¹⁷ The State Council (2009): *Guanyu Shenhua Yiyao Weisheng Tizhi Gaige de Yijian* (Guidance on Deepening Health and Medical Institutional Reform), Beijing, policy document. <http://www.moh.gov.cn/publicfiles/business/htmlfiles/mohzcfgs/s7846/200904/39847.htm>

¹⁸ The State Council (2007): *Guanyu Kaizhan Chengzhen Jumin Jiben Yiliao Baoxian Shidian de Zhidao Yijian* (Guidance on Pilot Experiment of Basic Medical Insurance for Urban Residents), (Guo Fa [2007] No.20), Beijing, policy document.

healthcare to the employees of the government agencies and public institutions. The BMISUE is financed with a payroll tax, nominally divided between employer and employee (Eggleston & Yip, 2004; Tang et al., 2008; Dong, 2009).

2.2.2 Strengthen government role in healthcare supply

The Chinese government took full responsibility in healthcare supply before economic reform in 1978. All hospitals were state-owned and all health workers were paid by the government. Following the economic reform, the government has tried to retreat from supplying healthcare and has introduced market mechanisms in the health sector. From the early 2000s, however, the government committed to increase spending and strengthen its role in healthcare supply. This implicates a returning back to a government-led health sector.

Statistically, aggregate healthcare expenditures in China increased from 11.02 billion Yuan in 1978 to 112.89 billion Yuan in 2007.¹⁹ Supply in healthcare didn't increase accordingly with the rapid increase in demand. From 1978 to 2007, the number of health workers, the number of hospital beds and the number of health institution only increased from 3.11 billion to 5.91 billion, from 2.04 billion to 3.70 billion, and from 169.73 thousand to 298.41 thousand respectively.²⁰

Since the first reform in 1985, the government has reduced spending in healthcare and requires hospitals to sustain financially themselves. Government spending as a share of total health expenditure decreased from 32.2% to 15.7% between 1978 and 2002.²¹ Without universal health insurance coverage, prices for basic healthcare were set below cost by the government to assure access to healthcare. To allow hospitals to recover revenue, the government sets prices for new and high-tech diagnostic services above cost and allows a 15% profit margin on drugs (Yip & Hsiao, 2009). Eggleston and Yip (2004) noted that the average percentage of Chinese public hospital income from governments shrank from 17% in 1985 to 7% in 1999. Over the same period an increasing percentage of public hospital income came from user fees (26 to 37%) and drug sales (39% to 50%). The decrease in

¹⁹ See "China Healthcare Statistical Yearbook 2009"

²⁰ See Appendix A for data in detail.

²¹ See Appendix B for data in detail.

government subsidies has caused a significant reliance of public hospitals on non-state revenues, primarily in the form of user fees and drug sales. And the pricing scheme for healthcare and drugs has caused distorted incentives for hospitals which over-prescribe drugs and high-tech procedures. This is a root cause of reduced access to and rapidly increasing expenditure on healthcare.

Actually the Chinese government has recognized the distorted incentive of the pricing scheme and has intended to reduce the distortion since the early 2000s. In October 2001, the Ministry of Finance, the Ministry of Health and other related bureaus issued “Guidance on improving compensation institution and implement compensation policy of urban healthcare facilities”. The document announced to gradually increase prices of professional services, reduce prices of large-scale health equipment test, encourage local government to increase investment into healthcare and implement financial subsidy policy to public non-profit hospitals.

In 2007, the minister of Health Chen Zhu said in an interview that the core idea of public hospital reform was to reform the compensation institution. Currently, there are three compensation streams for public hospitals - government subsidies, user charges and revenue from drug sales. Since government spending in healthcare has been in serious shortage for a long time and government subsidies as a share in health expenditure is only 17%, health institutions primarily rely on user charges and drug sales to sustain financially. The reform intends to gradually reduce hospitals’ profit-seeking behavior from drug sales. And to maintain public hospital operation, either government subsidies or user charges should be increased to replace hospital revenue from selling drugs.

In April 2009, a new healthcare reform plan was launched in China. In the plan, the government announced that it will spend an additional 850 billion Yuan over the next three years in healthcare. Two of the five specific areas that the plan intends to invest are increasing government spending on public health services and reforming the pharmaceutical market.

2.2.3 Improve efficiency in healthcare utilization

Another implication of reforms in the health sector is the inefficiency in healthcare utilization. Some studies have documented inefficiencies in healthcare utilization in China. The high grade hospitals in urban areas are often overcrowded with patients. Long queues wait in doctors' waiting rooms and rampant scalpers resell medical appointments at extortionately high prices; patients pay under-the-table payment to doctors with the intention to receive privileged treatment (Eggleson, et al., 2008; Kou & Shi, 2009). At the same time, the low grade hospitals and clinics are underutilized and patronized by few patients. This leads to an imbalance between demand for and supply of healthcare resources.

Zhou (2008) asserts that the price regulation in the health sector is one plausible reason. Wherever there is a need to queue up, the price is undervalued. The existence of scalpers reselling appointment numbers in leading hospitals indicates severe under-pricing. Zhou regards under-the-table payment is a natural reflection of the distorted price in the health sector. People are willing to pay more for health service but the price is regulated. Some other scholars assert there is distrust in lower grade hospitals. People are worried that they could not get good treatment in community hospitals which are among low-grade hospitals. Even if it takes long time to get treated in higher grade hospitals, they still choose leading hospitals. Scholars therefore suggest that more subsidies should provide to improve health services in community hospitals (Yang & Liu, 2008).

Pilot projects have been implemented at a sub national level to disperse patients from high grade hospitals to low grade hospitals. For example, in Shanghai, the Basic Medical Insurance Scheme reimburses a higher share of health expenditure for people visiting community hospitals compared to higher grade hospitals for certain diseases. In Beijing, People's Hospital of Beijing University – a third grade hospital – established a “healthcare community” with two community healthcare centers and 16 community healthcare clinics in September 2007. Within the community, healthcare institutions share information and resources and implement mutual transfers. The community aims at guiding people to “community hospitals with simple ailments and large hospitals with serious diseases”

(commonly phased “xiaobing zai shequ, dabing jin yiyuan” in Chinese) (Bai, 2001; Bai, 2008).

However, there is no nationwide program targeting the problem yet. As Yip & Hsiao (2009) stated, the new reform announcement in April 2009 “is less specific on how to improve efficiency and quality within the health system. The announcement's call for a “pilot” of public hospital reform is akin to an admission that more research must be done before more specific policy guidelines can be drawn up in this area.”

3 An Analytical Study

In this chapter, I develop a quality competition model of hospitals under regulated prices. The purpose of this model is to show the effect of different price regulation on hospitals' behaviors and demand for healthcare services. I use different cost coefficients to capture the difference between high-grade hospitals and low-grade hospitals. When price difference is very small, expanding it appropriately could give high-grade hospitals more incentive to improve quality of healthcare services and competition could urge low-grade hospitals to keep certain level of healthcare quality. Since people attach great value to health and pay great attention to qualities of healthcare services, high quality would lead to high demand for healthcare services and also high utility level of patients. Expanding the price difference between hospitals appropriately when existing price difference is small could bring about positive effects from the aspects of healthcare quality and patients' utilities.

3.1 The basic model

3.1.1 Framwork

We consider a price-regulated healthcare market with two hospitals, labeled as H and L. H denotes high-grade and L low-grade. Their prices are exogenously fixed at p .

Patients' healthcare demand to hospital i not only depends on the quality of service provided by hospital i but also the quality of service provided by its competitor. Since people have to pay healthcare service out-of-pocket or at least pay part of the total expenditure, demand for healthcare also depends on price. Let q_h and q_l be the number of patients wanting treatment at hospital H and L respectively. Let u_h and u_l be the quality of services provided by hospital H and L respectively. A demand function for H and L is assumed to be $q_h = \alpha - \beta p + u_h - \gamma u_l$ and $q_l = \alpha - \beta p + u_l - \gamma u_h$ respectively, where α is a constant term, β is a very small positive number and $\gamma \in (0,1)$. I will discuss these coefficients in more detail below.

By investing more effort, hospitals can increase quality. Effort imposes a disutility on a hospital. Let C_i denote the total cost of treating q_i patients when hospital i chooses quality u_i . Hospitals are assumed to have a total cost function $C_h = c_h u_h q_h$ and $C_l = c_l u_l q_l$, where c_h and c_l are fixed coefficients.

This thesis considers self-interested hospitals seeking to maximize profit by choosing service quality when service prices are regulated and set by government. Hospital H's Profit function is given by

$$\pi_h = p(\alpha - \beta p + u_h - \gamma u_l) - c_h u_h (\alpha - \beta p + u_h - \gamma u_l)$$

And hospital L's Profit function is given by

$$\pi_l = p(\alpha - \beta p + u_l - \gamma u_h) - c_l u_l (\alpha - \beta p + u_l - \gamma u_h)$$

3.1.2 Interpretations of parameters

1. γ is positive and assumed to be less than one (i.e. $\gamma \in (0,1)$). The interpretation is that services provided by different hospitals are not perfect substitutes. It implies that although prices are the same, when one hospital provides higher quality than the other, there are still some patients visiting the latter one. One plausible reason is that patients take into account transportation cost when choosing hospitals. When hospitals are located at different places, people tend to choose the nearest one when quality is similar.
2. u_h and u_l represent service quality of hospital H and L respectively. A natural measurement of a hospital's service quality is the treatment outcome of patients' illness. For patients, the better the treatment outcome, the higher their utility from treatment. So u_h and u_l also represent patients' utilities from hospital treatment.
3. Assume $c_h < c_l$. The assumption means that the high-grade hospital has a lower cost coefficient than the low-grade hospital. I provide two arguments for this assumption. First, hospitals are affected by their reputation. Even though the actual services provided by two hospitals are exactly the same, patients may still believe the service quality of the high-grade hospital is better. This psychological effect exists in healthcare. Due to

this effect, high-grade hospitals need less effort to produce the same level of utility for patients. Another argument is that a high-grade hospital has more health resources and provides a large scope for healthcare services, which generates economics of scale and economics of scope. Hence it is reasonable to assume $c_h < c_l$.

3.1.3 Hospitals' strategic choices

With previous assumptions, hospital H's objective function is given by $\max_{u_h}(pq_h - c_h u_h q_h)$ subject to $q_h = \alpha - \beta p + u_h - \gamma u_l$. We get the first-order condition:

$$\frac{\partial \pi_h}{\partial u_h} = p - c_h(\alpha - \beta p + u_h - \gamma u_l) - c_h u_h = 0$$

Rearranging the expression, we get the reaction function of hospital H:

$$u_h = p\left(\frac{1}{2c_h} + \frac{\beta}{2}\right) + \frac{\gamma}{2}u_l - \frac{\alpha}{2} \quad (1)$$

Similarly, the reaction function of hospital L is

$$u_l = p\left(\frac{1}{2c_l} + \frac{\beta}{2}\right) + \frac{\gamma}{2}u_h - \frac{\alpha}{2} \quad (2)$$

With (1) and (2), we get the equilibrium solution of service qualities:

$$a) \quad u_h^p = \frac{p}{4-\gamma^2} \left(\frac{2}{c_h} + \frac{\gamma}{c_l} + \beta(2+\gamma) \right) - \frac{\alpha}{2-\gamma} \quad (3)$$

$$u_l^p = \frac{p}{4-\gamma^2} \left(\frac{2}{c_l} + \frac{\gamma}{c_h} + \beta(2+\gamma) \right) - \frac{\alpha}{2-\gamma} \quad (4)$$

And the equilibrium quantity of healthcare services is defined by:

$$b) \quad q_h^p = \frac{p}{4-\gamma^2} \left((2-\gamma^2) \frac{1}{c_h} - \frac{r}{c_l} - (2+\gamma)\beta \right) + \frac{\alpha}{2-\gamma} \quad (5)$$

$$q_l^p = \frac{p}{4-\gamma^2} \left((2-\gamma^2) \frac{1}{c_l} - \frac{r}{c_h} - (2+\gamma)\beta \right) + \frac{\alpha}{2-\gamma} \quad (6)$$

We obtain the quality difference $\Delta u^p = u_h^p - u_l^p = \frac{p}{2+\gamma} \cdot \frac{c_l - c_h}{c_h c_l} > 0$. Under the same regulated price, the high-grade hospital provides a higher service quality.

3.2 The model under different regulated prices

Consider the case of different regulated prices for services of hospital H and L, denoted p_h and p_l respectively. It is rational to assume $p_h > p_l$. In this case, hospital H's profit function becomes $\pi_h = p_h(\alpha - \beta p_h + u_h - \gamma u_l) - c_h u_h(\alpha - \beta p_h + u_h - \gamma u_l)$. And its objective function becomes $\max_{u_h}(p_h q_h - c_h u_h q_h)$, subject to $q_h = \alpha - \beta p_h + u_h - \gamma u_l$.

The first order condition of hospital H is

$$\frac{\partial \pi_h}{\partial u_h} = p_h - c_h(\alpha - \beta p_h + u_h - \gamma u_l) - c_h u_h = 0$$

Again we obtain the reaction function of hospital H and hospital L:

$$u_h = p_h \left(\frac{1}{2c_h} + \frac{\beta}{2} \right) + \frac{\gamma}{2} u_l - \frac{\alpha}{2} \quad (7)$$

$$u_l = p_l \left(\frac{1}{2c_l} + \frac{\beta}{2} \right) + \frac{\gamma}{2} u_h - \frac{\alpha}{2} \quad (8)$$

The solution of hospitals' problem is given by:

$$c) \quad u_h^* = \frac{1}{4-\gamma^2} \left(2p_h \left(\frac{1}{c_h} + \beta \right) + \gamma p_l \left(\frac{1}{c_l} + \beta \right) \right) - \frac{\alpha}{2-\gamma} \quad (9)$$

$$u_l^* = \frac{1}{4-\gamma^2} \left(2p_l \left(\frac{1}{c_l} + \beta \right) + \gamma p_h \left(\frac{1}{c_h} + \beta \right) \right) - \frac{\alpha}{2-\gamma} \quad (10)$$

$$d) \quad q_h^* = \frac{p_h}{4-\gamma^2} \left((2-\gamma^2) \frac{1}{c_h} - 2\beta \right) - \frac{\gamma p_l}{4-\gamma^2} \left(\frac{1}{c_l} + \beta \right) + \frac{\alpha}{2-\gamma} \quad (11)$$

$$q_l^* = \frac{p_l}{4-\gamma^2} \left((2-\gamma^2) \frac{1}{c_l} - 2\beta \right) - \frac{\gamma p_h}{4-\gamma^2} \left(\frac{1}{c_h} + \beta \right) + \frac{\alpha}{2-\gamma} \quad (12)$$

The quality difference is $\Delta u^* = u_h^* - u_l^* = \frac{1}{2+\gamma} [p_h(\frac{1}{c_h} + \beta) - p_l(\frac{1}{c_l} + \beta)]$.

Since $p_h \geq p_l$ and $c_h < c_l$, we have $\Delta u^* > 0$ which means high-grade would provide higher level of service quality.

The derivatives of the equilibrium qualities with respect to prices are presented below:

$$\frac{\partial u_h^*}{\partial p_h} = \frac{2}{4-\gamma^2} (\frac{1}{c_h} + \beta) > 0, \frac{\partial u_l^*}{\partial p_h} = \frac{\gamma}{4-\gamma^2} (\frac{1}{c_h} + \beta) > 0, \frac{\partial u_h^*}{\partial p_h} = \frac{2}{\gamma} \frac{\partial u_l^*}{\partial p_h};$$

$$\frac{\partial u_l^*}{\partial p_l} = \frac{2}{4-\gamma^2} (\frac{1}{c_l} + \beta) > 0, \frac{\partial u_h^*}{\partial p_l} = \frac{\gamma}{4-\gamma^2} (\frac{1}{c_l} + \beta) > 0, \frac{\partial u_l^*}{\partial p_l} = \frac{2}{\gamma} \frac{\partial u_h^*}{\partial p_l}.$$

Proposition 1: The equilibrium quality of healthcare service provided by hospital i increases when hospital i 's regulated price increases; the equilibrium quality of healthcare service provided by hospital i increases when its competitor's regulated price increase. ($i \in \{H, L\}$)

The economic interpretation of proposition 1 is that hospitals have high incentives to attract demand under a high regulated price by improving quality level of healthcare services so as to maximize profits. When a hospital has increased quality, the other hospital would increase quality also to compete for patients. This is why a hospital's equilibrium quality also increases when its competitor's regulated price increases.

Also, we can get the derivatives of the equilibrium demand with respect to prices:

$$\frac{\partial q_h^*}{\partial p_h} = \frac{1}{4-\gamma^2} \left((2-\gamma^2) \frac{1}{c_h} - 2\beta \right), \frac{\partial q_h^*}{\partial p_l} = -\frac{\gamma}{4-\gamma^2} \left(\frac{1}{c_l} + \beta \right) < 0$$

$$\frac{\partial q_l^*}{\partial p_l} = \frac{1}{4-\gamma^2} \left((2-\gamma^2) \frac{1}{c_l} - 2\beta \right), \frac{\partial q_l^*}{\partial p_h} = -\frac{\gamma}{4-\gamma^2} \left(\frac{1}{c_h} + \beta \right) < 0$$

Proposition 2: When its regulated price increases, change in demand for healthcare services provided by hospital i ($i \in \{H, L\}$) depends on the relative magnitude of the

cost coefficient and β ; its equilibrium demand decreases when competitor's regulated price increases.

The economic interpretation of proposition 2 is that although a hospital improves its healthcare quality when its competitor's regulated price increases, it has a lower improvement than its competitor and hence the demand for its healthcare services still decreases. The uncertainty of effect on demand of own price change is because patients consider both price and quality when choosing a hospital. When the improvement in quality is not large enough to compensate the increase in price, people would turn to the other hospital.

3.3 Effect of expanding price difference

In this section I analyze what would happen if increase p_h to p'_h and decrease p_l to p'_l while keeping u_l^* constant. More specifically, we want to see the effect on healthcare quality, demand for healthcare and patients' total utility after expanding the price difference and keeping u_l^* constant.

Define $\Delta p_l = p'_l - p_l < 0$ and $\Delta p_h = p'_h - p_h > 0$. Define $\Delta u_h = u_h^{**} - u_h^*$ and $\Delta u_l = u_l^{**} - u_l^*$. We rewrite the reaction function of hospital H and L after expanding price difference:

$$u_h^{**} = \frac{1}{4-\gamma^2} \left(2p'_h \left(\frac{1}{c_h} + \beta \right) + \gamma p'_l \left(\frac{1}{c_l} + \beta \right) \right) - \frac{\alpha}{2-\gamma}$$

$$u_l^{**} = \frac{1}{4-\gamma^2} \left(2p'_l \left(\frac{1}{c_l} + \beta \right) + \gamma p'_h \left(\frac{1}{c_h} + \beta \right) \right) - \frac{\alpha}{2-\gamma}.$$

1) When keeping the service quality of hospital L constant (i.e. $\Delta u_l = 0$), we find that

$$\Delta u_h > 0^{22} \quad (13)$$

²² See Appendix D for proof

Expanding price difference leads to a higher service quality of hospital H. The logic behind is as follows: When hospital L charges lower and hospital H charges higher, if hospital H and L keep their quality levels of healthcare services unchanged, some of hospital H's patients (and potential patients) will choose hospital L instead. Hence hospital H has to improve service quality to sustain enough demand.

2) When keeping hospital L's quality constant and expanding price difference, we get $\Delta q_l = \Delta p_l / c_l < 0$. Demand for healthcare services provided by hospital L decreases. This is because hospital H improves its quality and attracts a part of patients from hospital L. With respect to demand for hospital H and total demand, we get

$$\Delta q_h \begin{cases} > 0, \text{ if } \beta < 1/c_h \\ \leq 0, \text{ if } \beta \geq 1/c_h \end{cases}, \text{ and } \Delta(q_h + q_l) \begin{cases} > 0, \text{ if } \beta < 1/c_h + (2/c_l)(\Delta p_l / \Delta p_h) \\ \leq 0, \text{ if } \beta \geq 1/c_h + (2/c_l)(\Delta p_l / \Delta p_h) \end{cases}^{23}$$

Since $\Delta p_l / \Delta p_h < 0$, we have

$$\begin{cases} 0 < \beta < 1/c_h + (2/c_l)(\Delta p_l / \Delta p_h) & , & \Delta q_h > 0 & \Delta(q_h + q_l) > 0 \\ 1/c_h + (2/c_l)(\Delta p_l / \Delta p_h) \leq \beta < 1/c_h & , & \Delta q_h > 0 & \Delta(q_h + q_l) \leq 0 \\ \beta \geq 1/c_h & , & \Delta q_h \leq 0 & \Delta(q_h + q_l) < 0 \end{cases}$$

In the model, β measures the sensitivity of healthcare demand to changes in price. When $\beta < 1/c_h + (2/c_l)(\Delta p_l / \Delta p_h)$, healthcare demand is relatively price inelastic. Quality plays a critical role in the demand for healthcare services. In this case, the increase in demand for hospital H's healthcare service due to improvement in quality is so large that it exceeds the decrease in demand for service provided by hospital L. Hence total demand for healthcare services increases. When $\beta \geq 1/c_h$, people attach relative large weight to price, and expanding price difference would lead to decreasing access to healthcare. In this case, although hospital H improves quality level, demand for its healthcare service decreases since price increases. The effect of expanding price difference leads to decreased access to healthcare. When $1/c_h + (2/c_l)(\Delta p_l / \Delta p_h) \leq \beta < 1/c_h$, demand for healthcare services provided by hospital H increases after expanding price difference. But its increase is large

²³ See Appendix D for deduction in detail.

enough to offset decrease in demand for healthcare services provided by hospital L. Hence total demand for healthcare services decreases.

Discussions above imply that the effects of expanding price difference depend on the price elasticity of demand for healthcare services. Ringel et al. (2002) make a literature review on healthcare demand elasticity and find that price elasticity of demand for healthcare tends to center on -0.17. This is plausible. When people get sick, they will not be very price sensitive. Hence the case that $\beta < 1/c_h + (2/c_l)(\Delta p_l / \Delta p_h)$ stands a good chance. And it is worth while to further discuss the change in patients' utility in this case.

3) If $\Delta(q_h + q_l) > 0$, we find that $\Delta(q_h u_h + q_l u_l) > 0$.²⁴ When $\beta < 1/c_h + (2/c_l)(\Delta p_l / \Delta p_h)$, expanding price difference leads to increase in total demand for healthcare services. Hospital H would improve its quality level and treat more patients. Hospital L keeps its quality level constant. This implies that more patients are treated and more patients are serviced by better healthcare services. The compounding effects of increase in quality and quantity of healthcare services lead to a great improvement of patients' utility. Hence when expanding price difference leads to increasing demand for healthcare services, the total utility of patients also increases.

The discussions above are summarized in proposition 3.

Proposition 3: When increase p_h and decrease p_l simultaneously while keeping u_l^* constant, we get following results:

- i. $\Delta u_h > 0$;
- ii.
$$\begin{cases} 0 < \beta < 1/c_h + (2/c_l)(\Delta p_l / \Delta p_h) , \Delta q_h > 0 & \Delta(q_h + q_l) > 0 \\ 1/c_h + (2/c_l)(\Delta p_l / \Delta p_h) \leq \beta < 1/c_h , \Delta q_h > 0 & \Delta(q_h + q_l) \leq 0 ; \\ \beta \geq 1/c_h , \Delta q_h \leq 0 & \Delta(q_h + q_l) < 0 \end{cases}$$
- iii. $\Delta(q_h u_h + q_l u_l) > 0$ if $\Delta(q_h + q_l) > 0$.

²⁴ See Appendix D for proof.

4 Conclusion

In this article, I present a quality competitive model of hospitals under regulated price and analyze the effects of regulated prices on hospital behaviours and patients' utilities. Prices for healthcare services are regulated in China. Hospitals are classified into three grades. In my model, I capture the difference between high-grade hospitals and low grade hospitals with different cost coefficients. Expanding price difference among hospitals to coordinate demand and supply of different grade hospitals has been used by provincial governments in China. The purpose of this thesis is to provide a theoretical analysis of this policy.

The present analysis shows that expanding price difference has potential to promote high-grade hospitals to improve healthcare quality. This is a positive effect. However, the total utility of patients not only depends on healthcare quality but also accessibility to healthcare. When people's demand for healthcare is price inelastic or people attach a relatively small weight to price compared with quality, total demand for healthcare services would increase after expanding price difference and total utility level of patients would increase as well. But when people attach great value on price compared with quality, then total demand for healthcare services would decrease instead. The results of the model imply that the effect of expanding price difference is closely associated with the price elasticity of demand for healthcare.

The price elasticity of demand is affected by various factors, like income and health insurance coverage. Covered by health insurance, patients would be less sensitive to price and demand becomes less elastic. Arrow (1963) discussed the potential effect of health insurance on demand for healthcare. People with high income could afford more on healthcare and might be less price elastic. Hence the impact of expanding price difference depends on other socioeconomic conditions. In wealthy provinces where most residents are covered by various health insurance programs, expanding price difference is much likely to produce social welfare. However, in poor provinces with few populations covered by health insurance, the policy might not generate many positive effects and may even bring negative effects. Therefore policymakers need to pay attention to the comprehensive condition of the health sector when apply the strategy to hospitals.

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Appendix

Appendix A: Resources and Total Expenditure in the Health Sector

Year	Number of Health Worker	Number of Hospital Beds	Number of Health Institutions	Year	Number of Health Worker	Number of Hospital Beds	Number of Health Institutions
1978	3105572	204.17	169732	1994	5307009	313.40	191742
1980	3534707	218.44	180553	1995	5373378	314.06	190057
1981	3796121	223.38	190126	1996	5419002	309.96	322566
1982	3957804	228.03	193438	1997	5516176	313.45	315033
1983	4090030	234.16	196017	1998	5535682	314.30	314097
1984	4213646	241.24	198256	1999	5570048	315.90	300996
1985	4313011	248.71	200866	2000	5591026	317.70	324771
1986	4445919	256.25	203139	2001	5583932	320.12	330348
1987	4564122	268.50	204960	2002	5238079	313.61	306038
1988	4677512	279.49	205988	2003	5274786	316.40	291323
1989	4786959	286.70	206724	2004	5356589	326.84	297540
1990	4906201	292.54	208734	2005	5426851	336.75	298997
1991	5025134	299.19	209036	2006	5619515	351.18	308969
1992	5140246	304.94	204787	2007	5907052	370.11	298408
1993	5215416	309.90	193586	2008	6169050	403.87	278337

Source: China health Statistical Yearbook 2009, China Statistical Yearbook 2008, China Statistical Yearbook 1999

From 1978 to 2007, the number of health workers, hospital beds and health institutions has increased less than 1 time. But the total health expenditure has increased dramatically.

Appendix B: Total Health Expenditure Components

Year	Total Health Expenditure (100 million)				Total Health Expenditure Components (%)		
	Total expenditure	Government Expenditure	Social Expenditure	Individual Expenditure	Government Share	Social Share	Individual Share
1978	110.21	35.44	52.25	22.52	32.2	47.4	20.4
1979	126.19	40.64	59.88	25.67	32.2	47.5	20.3
1980	143.23	51.91	60.97	30.35	36.2	42.6	21.2
1981	160.12	59.67	62.43	38.02	37.3	39.0	23.7
1982	177.53	68.99	70.11	38.43	38.9	39.5	21.6
1983	207.42	77.63	64.55	65.24	37.4	31.1	31.5
1984	242.07	89.46	73.61	79.00	37.0	30.4	32.6

1985	279.00	107.65	91.96	79.39	38.6	33.0	28.5
1986	315.90	122.23	110.35	83.32	38.7	34.9	26.4
1987	379.58	127.28	137.25	115.05	33.5	36.2	30.3
1988	488.04	145.39	189.99	152.66	29.8	38.9	31.3
1989	615.50	167.83	237.84	209.83	27.3	38.6	34.1
1990	747.39	187.28	293.10	267.01	25.1	39.2	35.7
1991	893.49	204.05	354.41	335.03	22.8	39.7	37.5
1992	1096.86	228.61	431.55	436.70	20.8	39.3	39.8
1993	1377.78	272.06	524.75	580.97	19.7	38.1	42.2
1994	1761.24	342.28	644.91	774.05	19.4	36.6	43.9
1995	2155.13	387.34	767.81	999.98	18.0	35.6	46.4
1996	2709.42	461.61	875.66	1372.15	17.0	32.3	50.6
1997	3196.71	523.56	984.06	1689.09	16.4	30.8	52.8
1998	3678.72	590.06	1071.03	2017.63	16.0	29.1	54.8
1999	4047.50	640.96	1145.99	2260.55	15.8	28.3	55.9
2000	4586.63	709.52	1171.94	2705.17	15.5	25.6	59.0
2001	5025.93	800.61	1211.43	3013.89	15.9	24.1	60.0
2002	5790.03	908.51	1539.38	3342.14	15.7	26.6	57.7
2003	6584.10	1116.94	1788.50	3678.66	17.0	27.2	55.9
2004	7590.29	1293.58	2225.35	4071.35	17.0	29.3	53.6
2005	8659.91	1552.53	2586.41	4520.98	17.9	29.9	52.2
2006	9843.34	1778.86	3210.92	4853.56	18.1	32.6	49.3
2007	11289.50	2297.10	3893.72	5098.66	20.4	34.5	45.2

Source: China Healthcare Statistical Yearbook 2009.

Appendix C: Classification Standards for General Hospitals in China

Indicators and criteria for hospital classification mainly include five components:

1. Hospital scale, measured by four aspects which are the number of hospital beds, buildings, staff and department.
2. Hospital technical level;
3. Healthcare facilities;
4. Hospital's governance, measured by seven aspects which are director's qualities, work management, information management, modern management skills, hospital infection control, resource utilization and economic efficiency.
5. Hospital quality, measure by the following aspects: diagnosis quality, treatment quality, nursing quality, performance quality and comprehensive quality.

Some specific requirements for general hospitals have been summarized in following table.

Hospital classification	Hospital beds	Department setting (lowest requirements)	staffing
The 1st grade general hospital	20-99 beds	Clinical Departments: Emergency room, Internal Medicine, Surgery, Obstetrics and Gynecology, Preventive Medicine; Other Departments: Pharmacy, Laboratory, Radiology, Sterilization room.	At least 0.7 health worker per bed; At least 3 doctors, 5 nurses and corresponding pharmaceutical, testing and radiating health workers; At least 1 doctor holding the title attending physician or above (included in the 3 doctors)
The 2nd grade general hospital	100-499 beds	Clinical Departments: Emergency room, Internal Medicine, Surgery, Obstetrics and Gynecology, Preventive Medicine, Pediatrics, Ophthalmology, E.N.T., Stomatology, Dermatology, Infectious Disease; Other Departments: Pharmacy, Laboratory, Radiology, Physiotherapy, Sterilization room, Operating Room, Pathology, Blood bank, Medical records Department.	At least 0.88 health worker and 0.4 nurse per bed; At least 3 doctors holding the title associate chief physician or above; At least 1 doctor holding the title attending physician or above at each department.
The 3rd grade general hospital	>500 beds	Clinical Departments: Emergency room, Internal Medicine, Surgery, Obstetrics and Gynecology, Preventive Medicine, Pediatrics, Ophthalmology, E.N.T., Stomatology, Dermatology, Infectious Disease, Chinese Medicine, Rehabilitation; Other Departments: Pharmacy, Laboratory, Radiology, Physiotherapy, Sterilization room, Operating Room, Pathology, Blood bank, Medical records Department, Nuclear Medicine, Transfusion, Nutrition, Clinical function examination room.	At least 1.03 health worker and 0.4 nurse per bed; Doctors holding the title associate chief physician or above at each professional department; At least 2 clinical nutritionists; Engineering technical personnel (i.e. technician, assistant engineer or higher levels) should account for more than 1% of the staff.

Source: Ministry of Health (1990): "General Hospital Classification Management Standard (trial draft)" (in Chinese), Ministry of Health, Beijing, China.

Appendix D

Proof of expression (13):

Proof.

$$u_h^{*'} = \frac{1}{4-\gamma^2} \left(2p_h' \left(\frac{1}{c_h} + \beta \right) + \gamma p_l' \left(\frac{1}{c_l} + \beta \right) \right) - \frac{\alpha}{2-\gamma}$$

$$u_l^{*'} = \frac{1}{4-\gamma^2} \left(2p_l' \left(\frac{1}{c_l} + \beta \right) + \gamma p_h' \left(\frac{1}{c_h} + \beta \right) \right) - \frac{\alpha}{2-\gamma}$$

Combining the previous expression with expression (10), we get

$$\frac{1}{4-\gamma^2} \left(2p_l' \left(\frac{1}{c_l} + \beta \right) + \gamma p_h' \left(\frac{1}{c_h} + \beta \right) \right) - \frac{\alpha}{2-\gamma} = \frac{1}{4-\gamma^2} \left(2p_l \left(\frac{1}{c_l} + \beta \right) + \gamma p_h \left(\frac{1}{c_h} + \beta \right) \right) - \frac{\alpha}{2-\gamma}$$

$$\Leftrightarrow \frac{1}{4-\gamma^2} \left(2\Delta p_l \left(\frac{1}{c_l} + \beta \right) + \gamma \Delta p_h \left(\frac{1}{c_h} + \beta \right) \right) = 0$$

$$\Leftrightarrow 2\Delta p_l \left(\frac{1}{c_l} + \beta \right) + \gamma \Delta p_h \left(\frac{1}{c_h} + \beta \right) = 0$$

By defining $A = \frac{1}{c_h} + \beta$ and $B = \frac{1}{c_l} + \beta$, we can rewrite the previous equation as $\gamma \Delta p_h A + 2\Delta p_l B = 0$. Since $c_h < c_l$, we have $A > B > 0$. Since $\Delta p_h > 0$, we have $\Delta p_h A = -\frac{2\Delta p_l B}{\gamma} > 0$.

$$\Delta u_h = u_h^{*'} - u_h^* = \frac{2\Delta p_h A + \gamma \Delta p_l B}{4-\gamma^2} = \frac{2\Delta p_h A + \gamma \left(\frac{-\gamma \Delta p_h A}{2} \right)}{4-\gamma^2} = \frac{\Delta p_h A}{2} > 0$$

Since $\Delta p_h A > 0$, Δu_h is positive ($\Delta u_h > 0$).

Deduction of Δq_l , Δq_h and $\Delta(q_h + q_l)$:

$$\Delta q_l = \frac{\Delta p_l}{4-\gamma^2} \left((2-\gamma^2) \frac{1}{c_l} - 2\beta \right) - \frac{\gamma \Delta p_h}{4-\gamma^2} \left(\frac{1}{c_h} + \beta \right)$$

$$\Leftrightarrow \Delta q_l = \frac{\Delta p_l}{4-\gamma^2} \left((4-\gamma^2) \frac{1}{c_l} - 2\left(\frac{1}{c_l} + \beta\right) \right) - \frac{\gamma \Delta p_h}{4-\gamma^2} \left(\frac{1}{c_h} + \beta \right)$$

$$\Leftrightarrow \Delta q_l = \frac{\Delta p_l}{c_l} - \frac{2\Delta p_l}{4-\gamma^2} \left(\frac{1}{c_l} + \beta \right) - \frac{\gamma \Delta p_h}{4-\gamma^2} \left(\frac{1}{c_h} + \beta \right)$$

$$\Leftrightarrow \Delta q_l = \frac{\Delta p_l}{c_l} - \frac{1}{4-\gamma^2} \left(2\Delta p_l \left(\frac{1}{c_l} + \beta \right) + \gamma \Delta p_h \left(\frac{1}{c_h} + \beta \right) \right)$$

Since $2\Delta p_l \left(\frac{1}{c_l} + \beta \right) + \gamma \Delta p_h \left(\frac{1}{c_h} + \beta \right) = 0$, we have

$$\Delta q_l = \frac{\Delta p_l}{c_l} < 0.$$

$$\Delta q_h = \frac{\Delta p_h}{4-\gamma^2} \left((2-\gamma^2) \frac{1}{c_h} - 2\beta \right) - \frac{\gamma \Delta p_l}{4-\gamma^2} \left(\frac{1}{c_l} + \beta \right)$$

$$\Leftrightarrow \Delta q_h = \frac{\Delta p_h}{4-\gamma^2} \left((4-\gamma^2) \frac{1}{c_h} - 2\left(\frac{1}{c_h} + \beta\right) \right) - \frac{\gamma \Delta p_l}{4-\gamma^2} \left(\frac{1}{c_l} + \beta \right)$$

$$\Leftrightarrow \Delta q_h = \frac{\Delta p_h}{c_h} - \frac{1}{4-\gamma^2} \left(2\Delta p_h \left(\frac{1}{c_h} + \beta \right) + \gamma \Delta p_l \left(\frac{1}{c_l} + \beta \right) \right)$$

Since $2\Delta p_l \left(\frac{1}{c_l} + \beta \right) + \gamma \Delta p_h \left(\frac{1}{c_h} + \beta \right) = 0$, we have $\Delta p_l \left(\frac{1}{c_l} + \beta \right) = -\frac{\gamma}{2} \Delta p_h \left(\frac{1}{c_h} + \beta \right)$. Then

$$\text{we get } \Delta q_h = \frac{\Delta p_h}{c_h} - \frac{1}{4-\gamma^2} \left(2\Delta p_h \left(\frac{1}{c_h} + \beta \right) - \frac{\gamma^2}{2} \Delta p_l \left(\frac{1}{c_l} + \beta \right) \right)$$

$$\Leftrightarrow \Delta q_h = \frac{\Delta p_h}{2c_h} - \frac{\Delta p_h}{2} \beta$$

$$\Delta q_h = \frac{\Delta p_h}{2} \left(\frac{1}{c_h} - \beta \right)$$

When $\beta < \frac{1}{c_h}$, we have $\Delta q_h > 0$; otherwise, $\Delta q_h \leq 0$.

$$\text{i.e. } \Delta q_h \begin{cases} > 0, \text{ if } \beta < 1/c_h \\ \leq 0, \text{ if } \beta \geq 1/c_h \end{cases}$$

Since $\Delta(q_h + q_l) = \Delta q_h + \Delta q_l = \frac{\Delta p_h}{2c_h} - \frac{\Delta p_h}{2} \beta + \frac{\Delta p_l}{c_l}$, we have

$$\Delta(q_h + q_l) = \frac{\Delta p_h}{c_l} \left(\frac{c_l}{2c_h} - \frac{c_l}{2} \beta + \frac{\Delta p_l}{\Delta p_h} \right).$$

When $\frac{c_l}{2c_h} - \frac{c_l}{2} \beta + \frac{\Delta p_l}{\Delta p_h} > 0$, or $\beta < \frac{1}{c_h} + \frac{2}{c_l} \frac{\Delta p_l}{\Delta p_h}$, we have $\Delta(q_h + q_l) > 0$; otherwise,

$$\Delta(q_h + q_l) \leq 0.$$

$$\text{i.e. } \Delta(q_h + q_l) \begin{cases} > 0, \text{ if } \beta < 1/c_h + (2/c_l)(\Delta p_l / \Delta p_h) \\ \leq 0, \text{ if } \beta \geq 1/c_h + (2/c_l)(\Delta p_l / \Delta p_h) \end{cases}$$

Since $\Delta p_l / \Delta p_h < 0$, we have $1/c_h + (2/c_l)(\Delta p_l / \Delta p_h) < 1/c_h$. Hence, we get the following results:

$$\begin{cases} 0 < \beta < 1/c_h + (2/c_l)(\Delta p_l / \Delta p_h) , \Delta q_h > 0 & \Delta(q_h + q_l) > 0 \\ 1/c_h + (2/c_l)(\Delta p_l / \Delta p_h) \leq \beta < 1/c_h , \Delta q_h > 0 & \Delta(q_h + q_l) \leq 0 \\ \beta \geq 1/c_h & , \Delta q_h \leq 0 \quad \Delta(q_h + q_l) < 0 \end{cases}$$

Proof of expression $\Delta(q_h u_h + q_l u_l) > 0$ when $\Delta(q_h + q_l) > 0$:

Proof.

$$\begin{aligned} \Delta(u_h q_h + u_l q_l) &= (q_h^{*'} u_h^{*'} + q_l^{*'} u_l^{*'}) - (q_h^* u_h^* + q_l^* u_l^*) \\ \Leftrightarrow \Delta(q_h u_h + q_l u_l) &= (q_h^{*'} u_h^{*'} - q_h^* u_h^*) + (q_l^{*'} u_l^{*'} - q_l^* u_l^*) \\ \Leftrightarrow \Delta(q_h u_h + q_l u_l) &= (q_h^{*'} u_h^{*'} - q_h^* u_h^*) + (q_h^{*'} u_h^* - q_h^* u_h^*) + (q_l^{*'} u_l^* - q_l^* u_l^*) \\ \Leftrightarrow \Delta(q_h u_h + q_l u_l) &= q_h^{*'} \Delta u_h + \Delta q_h u_h^* + \Delta q_l u_l^* \\ \Leftrightarrow \Delta(q_h u_h + q_l u_l) &= q_h^{*'} \Delta u_h + \Delta q_h u_h^* + \Delta q_l u_h^* - \Delta q_l u_h^* + \Delta q_l u_l^* \\ \Leftrightarrow \Delta(q_h u_h + q_l u_l) &= q_h^{*'} \Delta u_h + (\Delta q_h + \Delta q_l) u_h^* - \Delta q_l \Delta u^* \\ \Leftrightarrow \Delta(q_h u_h + q_l u_l) &= q_h^{*'} \Delta u_h + \Delta(q_h + q_l) u_h^* - \Delta q_l \Delta u^* \end{aligned}$$

Since $\Delta u_h > 0$, $\Delta(q_h + q_l) > 0$, $\Delta q_l < 0$ and $\Delta u^* > 0$, we have $\Delta(q_h u_h + q_l u_l) > 0$.